Anti-ultraviolet Treatment for Cotton Fabrics by Dyeing and Finishing in one Bath and Two Steps

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Abstract: In this study, a new approach to a UV-blocking treatment for cotton fabrics was developed by dyeing and finishing in one bath and two steps. In this approach, nano-TiO_2 was used as inorganic anti-ultraviolet agent, adhesives poly (vinyl pyrrolidone) PVP was used to improve the wet fastness. Ultraviolet Spectrometer was used for testing and analysis the anti-ultraviolet ability of the cotton fabric before and after the nano-TiO_2 finishing. The effect of the anti-ultraviolet performance and wet fastness of cotton fabrics with different content of nano-TiO_2 or adhesives were investigated. The results show that the nano-TiO_2 UV finishing can effectively improve the UV blocking ability of cotton fabric. With the increase usage of nano-TiO_2, the UV blocking ability of the treated cotton fabrics was increasing. Wet fastness was decreasing when there was no PVP adhesive while it was increasing when there was PVP adhesive and the ability of UV blocking was also increasing. But the content should be controlled in a moderate range; the ability of UV blocking would decrease if the content was exceeding the appropriate range. The electronic fabric strong-tensile machine was used for testing the tearing and breaking tenacity of the treated fabric and the computer-permeability tester was used for testing its air permeability. The results show that the treatment of nano-TiO_2 in this approach for UV-blocking treatment had little effect on the wear ability of the cotton fabric.

Keywords: anti-ultraviolet, cotton fabrics, Nano -TiO_2, PVP adhesive, finishing

1. Introduction

Since the 20th century , due to the increasingly use of Freon solutions, the ozonosphere on the earth aerosphere has been severely destroyed, the amount of ultraviolet radiation that reaches the surface of the earth has been increasing, which is more and more seriously affecting the health of human beings [1, 3]. Although people have taken universal education and use of sunscreen extensively, the incidence of skin cancer is rising. There are many factors of getting skin cancer, but now the factor of long-term radiation by ultraviolet ray has been recognized as an important one [4, 5]. So it is very urgent to research and empolder anti-ultraviolet radiation products, in order to protect from excessive UV radiation. And now, nano materials are used for producing UV-protective textile and enjoys by academic circles and business enterprise field, because of its excellent characteristics [6, 8]. There are many opportunities and challenges on the development of UV-protection clothing, because we should know how it can successfully applied to textiles, including having last characteristics of UV-production, having no effect on textile (such as hand, permeability) and also should consider the feasibility of techniques and cost-effectiveness of products [9].

At present, the nanotechnology worldwide-used in the fabric UV-proof finishing can be mainly divided into three different ways, including implanting, spinning, printing and dyeing.

In the implanting method [10], the anti-ultraviolet nanoparticles are firmly absorbed into the micro-pores on the surface of natural fibers or natural fiber fabrics by special treatment way, endowing the treated fibers or fabrics with anti-ultraviolet function. This method has solved two world-famous problems about the dispersion and fixation of nanoparticles in the natural or chemical fibers. But this technique is very difficult, and it cannot be widely used.

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In the spinning method [11], the anti-ultraviolet nanoparticles are dispersed and melted into the polymer solution and spun into fibers. This method can ensure the firmly combination of the UV- proof agents with the fabrics, but it has complex technique, low production rate, high costs. Moreover, it can be only used for the treatment of chemical fibers. While in the printing or dyeing method [12] the UV-proof agents are mixed into the color paste, dispersed and combined with the textile product in the printing or dyeing process. This can ensure the good dispersion of nanoparticles. Although the products treated by this method have low wet fastness and the functions cannot be maintained long time, but it is simple and quite workable.

In this study, we improved on the printing or dyeing method. The dyeing and finishing are carried out in one bath and two steps to avoid the degradation of dye caused by TiO_2 and save the water. Nano-TiO_2 is used as inorganic anti-ultraviolet agent, poly (vinyl pyrrolidone) PVP is used as an adhesive to increase the wet fastness of treated fabric and maintain its longstanding functions to overcome the disadvantage of the printing or dyeing method. Polyethylene glycol 400 is used as softening and dispersion agent to improve the mechanical and physical properties of treated fabrics.

2. Experiments

2.1 Materials

Cotton fabric (100% bleached cotton plain fabric purchased from Taiwan), nano-TiO_2 (provided by the Institute of Polymer Composite [IPC] of Zhejiang University, about 50 nm), reactive orange K-G, dispersion NNO, ethanol (Wuxi Longjili Chemicals Co.Ltd), penetrating agent JNC, polyethylene glycol 400 (Shanghai Pudong Gaonan Chemicals Co.,Ltd), polyvinylpynolidone (PVP, China Medicine Group Shanghai Chemicals Reagent Co.,Ltd), all the other reagents were analytical grade, and were used without further purification.

2.2 The preparation of nano-TiO_2 dispersion solution

After weighing the needed TiO_2 powder into 4 middle-size beakers, add adequate ethanol to the beakers and then put them into the ultrasonic shaker to shake for 10 min, stirring with glass rod continuously.

2.3 Dyeing and nano-TiO_2 anti-ultraviolet treatment for cotton fabric

Table 1
Dyeing recipe

item	dosage
reactive dye /%	2
NNO/g/L	1
NaCl /g/L	20(used in two times)
Na_2CO_3/g/L	10
scour/g/L	1
dyeing time/min	30
dyeing temperature/℃	60
dye fixing time/min	60
dye fixing temperature/℃	70
soap-boiling time /min	15
soap-boiling temperature /℃	95-100
bath ratio	1：30
PH	10
penetrating agent (JNC)	adequate

Table 1 is the dyeing recipe, and the anti-ultraviolet treatment recipe is adding different nano-TiO_2 and PVP, as shown in table 2, into the remainder of dyeing solution.

The dyeing and treatment procedure is as following:

Preparation of the nano-TiO_2 dispersion solution → dyeing solution preparation → adjusting the PH to 10 → dyeing (60 ˚C, 30 min) → dye fixation (70 ˚C, 30 min) → adding the nano-TiO_2 dispersion solution → nano-TiO_2 anti-ultraviolet treatment (70 ˚C, 30 min) → washing (40 ˚C water) → soaping (100 ˚C, 10 min) → washing (normal temperature) → drying (105 ˚C)

JFBI Vol.1 No. 1 2008 doi:10.3993/jfbi06200809